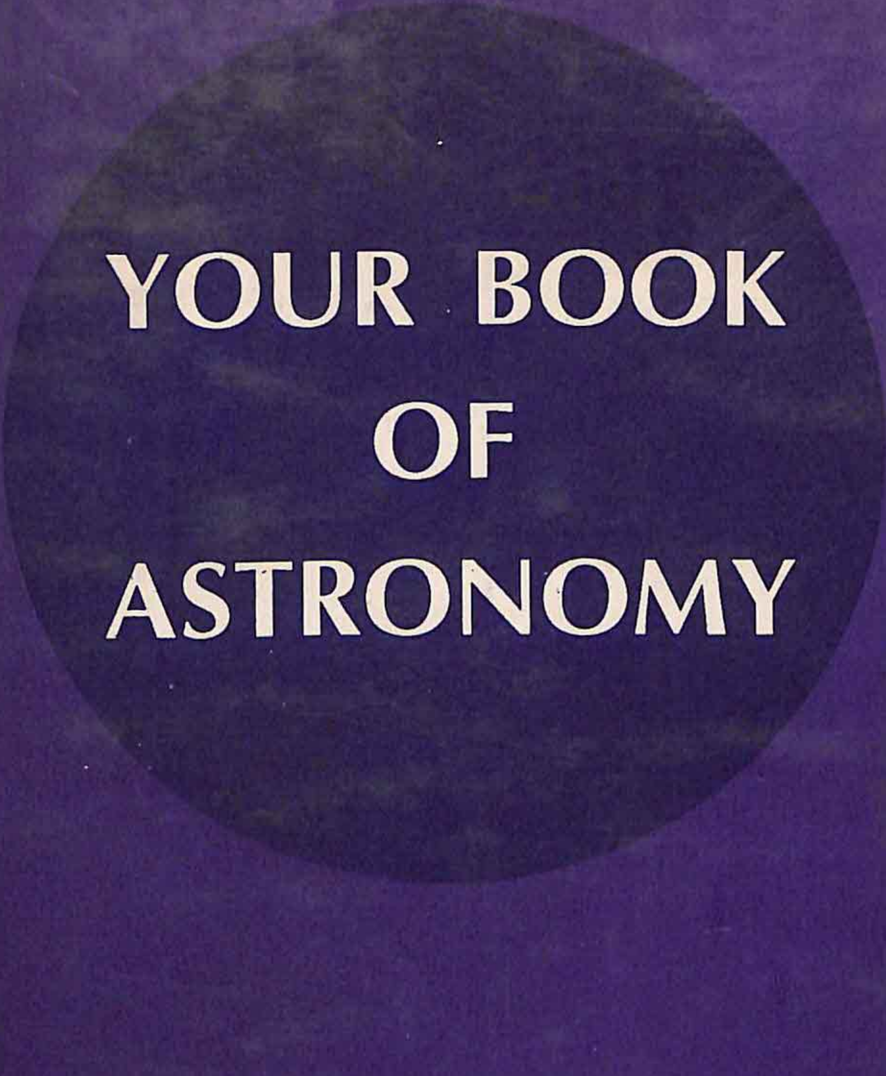

YOUR BOOK OF ASTRONOMY

PATRICK MOORE

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Your Book of Astronomy

The Great Comet of 1811

YOUR BOOK OF ASTRONOMY

by

PATRICK MOORE

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My thanks are also due to Miss Patricia Cullen, for providing some drawings; and to K. Stocker, who took several of the telescope photographs.

Neither must I omit to thank Ian Baker for allowing himself to be used as a 'demonstrator' in the telescope photographs.

Finally, I would like to record my appreciation of the unfailing help and encouragement given to me by the publishers.

Foreword to the Second Edition

Many interesting events have taken place since this book first appeared, five years ago. Without altering the basic plan, I have therefore taken the opportunity to bring the text up to date, and to include the latest results. I am very grateful to the publishers for allowing me to make these revisions.

PATRICK MOORE

February 1964

Introduction

Astronomy, the study of the stars and the other objects to be seen in the sky, is one of the best of all hobbies, because everybody can take an interest in it. It is not necessary to have a large telescope; you need not even have a telescope at all, though it is true that if you can buy or borrow a small instrument you will be able to find out far more than is possible by using your eyes alone.

Most people have a little knowledge of astronomy, perhaps enough for them to find the Plough and the Pole Star, but it is too often believed that all 'astronomers' are old men with white beards, who spend all their time in lonely observatories. Nothing could be further from the truth; many well-known amateur astronomers do all their work with telescopes set up in their back gardens.

If you decide to make a real hobby of astronomy, you will soon find others who have interests similar to your own, and you will make many new friends of your own age—whether you happen to be ten, twenty or even eighty years old! There is always something fresh to see in the sky, and you will be able to give yourself endless enjoyment.

Looking through a refractor

Stars and Planets

Thousands of years ago men believed the world to be flat. Nowadays, we know better; the Earth is a 'planet', a globe nearly 8,000 miles in diameter, revolving round the Sun in a period of one year. There are eight other planets, some larger than the Earth and some smaller.

One of the unfamiliar things about astronomy is its distance scale. We are used to regarding '1,000 miles' as a long journey, but 1,000 miles is a mere nothing to the astronomer. The distance between the Earth and the Sun is 93 million miles, so that if we could do the trip by aeroplane, moving at a steady 200 m.p.h., we would be over fifty years on the way. The outermost of the planets, Pluto, lies at a distance of more than 3,000 million miles from the Sun.

It is not easy to understand distances of this sort, and it may be helpful to give a scale model. Let us represent the Sun by a ball 1 ft. across, which is about the size of a football. On this scale, the Earth will become a tiny globe smaller than a pea, and we shall have to put it at a distance of slightly over 100 ft. from the football. If you fix up this model in your garden, or in a field, you will have some idea of how small the Earth really is when we compare it with the Sun. The planet Pluto is even tinier than the Earth, but it will be hopeless to try to put it at its correct distance unless you build the model in a very large field; the distance between Pluto and our football-Sun will be about a mile.

The Sun is quite unlike the Earth. Not only is it much larger, but it is also very hot, with a surface temperature of about 10,000° F. Neither is it 'solid'; its surface is made up of luminous gas. The Sun is a star, and it comes as a surprise to some people to learn that the stars which we see at night-time are themselves suns, many of them far larger and hotter than ours. The best way to explain the difference between a star and a planet is to say that the Sun is an ordinary star, while the Earth is an ordinary planet.

The only reason why the Sun appears so much brighter than the other stars is that it is much closer to us. On our scale, the nearest of the stars will lie some 4,000 miles from the football; if the football is placed in London, the ball representing the nearest star will have to be taken across the Atlantic and set down in the middle of the United States of America.

The old Latin word for 'sun' was *sol*, and so the Sun's family, made up of the planets and various smaller bodies, is called the Solar System. The Solar System seems very important to us, because it is our home in space, but we must always remember that it makes up only a very small part of the universe.

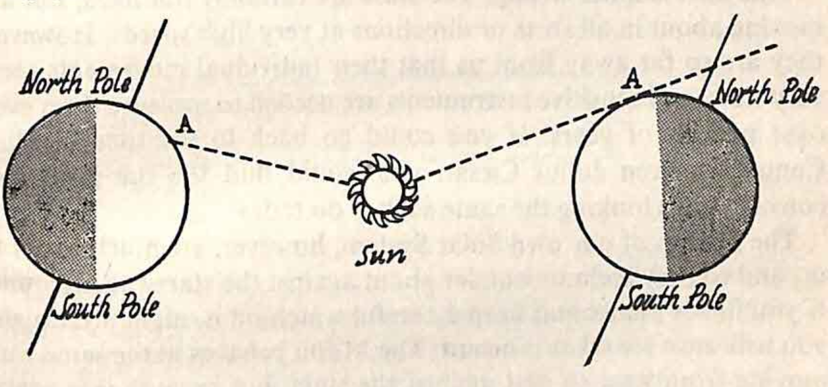
Of course, the stars do not revolve around the Sun; they are suns in their own right, and are quite independent. Because they are so far away, no telescope yet built will show them as anything but tiny points of light, even though they are really so large.

The star-system, or Galaxy, contains a great many stars. Altogether it seems that there are about one hundred thousand million separate suns in the Galaxy, and it is very probable that many of them have planet-families of the same type as our Solar System.

The Earth is at least four thousand million years old, but nobody is quite sure of the way in which it was born. According to one theory, which may well be correct, the Earth and planets were formed from material collected by the Sun from a cloud of gas and dust in space.

How the Earth Moves

The time taken by the Earth to go once round the Sun is 365¼ days. For our ordinary calendar, we say that one 'year' is exactly 365 days, but this is a quarter of a day too short—so that every four years we have to add an extra day, giving February 29 days instead of the usual 28, to keep our calendars correct. This is why we have 'leap year'.



June December

The Earth's path round the Sun is not quite circular, and we are actually closest to the Sun in January, during the northern winter. The seasons are due not to the varying distance of the Sun, but to the fact that the Earth's axis of rotation is tipped, as shown here. In our winter, the northern part of the Earth is tilted away from the Sun, while in summer the northern hemisphere is tilted toward the Sun. If you stand at any particular point (the front door of your house, for instance) at midday, and measure the height of the Sun above the horizon by comparing it with convenient trees or rooftops, you will see that the Sun rises much higher in the summer.

As well as revolving round the Sun, the Earth spins on its axis once a day. Since the direction of spin is from west to east, all the bodies in the sky seem to move in the opposite direction, which is why the Sun rises in the east and sets in the west. This apparent movement has nothing to do with the Sun itself, but is due entirely to the Earth's rotation.

The stars seem to move across the sky 'all together', so to speak, just as specks of mud upon a football will do if you spin the football round. The old astronomers of thousands of years ago thought that the stars were really fixed in space, and so they called them 'Fixed Stars'.

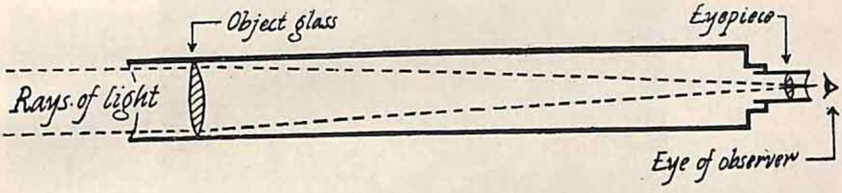
This idea is quite wrong. The stars are certainly not fixed, but are moving about in all sorts of directions at very high speeds. However, they are so far away from us that their individual movements seem very slow, and sensitive instruments are needed to measure them even over periods of years. If you could go back to the time of King Canute, or even Julius Cæsar, you would find the star-groups or constellations looking the same as they do today.

The planets of our own Solar System, however, are much closer to us, and so they seem to wander about against the starry background. If you find a planet and keep a careful watch on it, night after night, you will soon see what is meant. The Moon behaves in the same way, moving from west to east against the stars, but because it is nearer than any of the planets it seems to move even more quickly.

How A Telescope Works

Though you can enjoy astronomy even if you have no instrument, it is a great help to obtain either a pair of good binoculars, or else a small telescope.

Astronomical telescopes are of two types. The first is the Refractor, which collects its light by means of a glass lens known as an object-glass. The picture shows how it works.



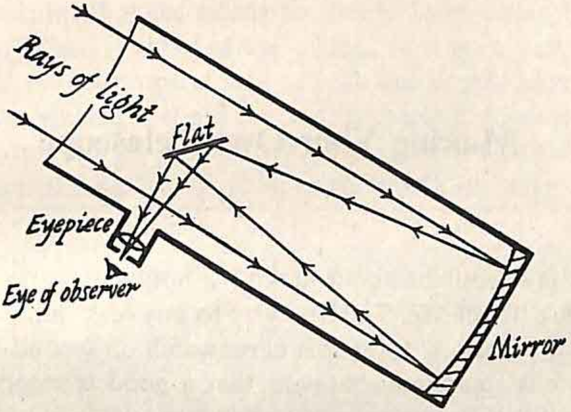
Let us suppose that we are going to observe the Moon. We point the telescope in the right direction, and the moonlight falls on to the object-glass. The rays of light are bent, and bunched together at a point known as the focus. At the focus, an image of the Moon is produced, and this image is enlarged by a second lens known as an eyepiece, which is really nothing more than a special kind of magnifying-glass. Every telescope has several eyepieces, so that by changing the eyepiece, we can alter the magnification.

The second type of telescope, the Reflector, has no object-glass at all. The light from the Moon, or whatever object we are observing, comes down an open tube, and falls upon a mirror at the bottom. This mirror is curved, and directs the light-rays on to a second,

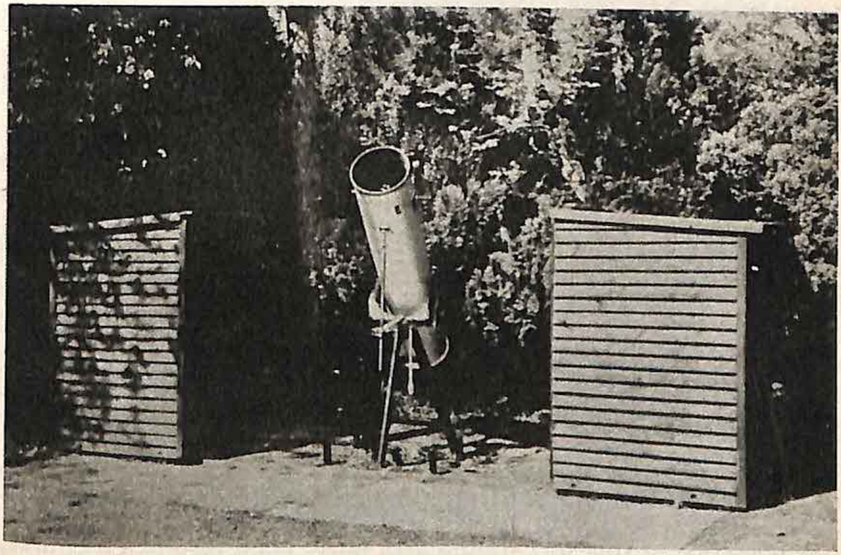
Looking through a reflector

smaller mirror or 'flat'. The flat sends the rays to the side of the tube, where they are brought to focus and the image is magnified by an eyepiece as before. With a reflector, the observer looks 'into' the tube instead of 'up' it.

One curious fact is that an astronomical telescope gives an upside-down picture, so that south is at the top. Astronomers do not mind this in the least, but for other telescopes, such as those used by sailors, it is necessary to add some further lenses to turn the picture the right way up again.



How a reflector works

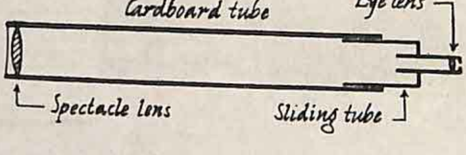


A 'run-off' observatory, mounted on rails. This arrangement is not so good as a dome, but it is far better than nothing! (This is my own 12½-inch reflector at East Grinstead)

Making Your Own Telescope

One of the few troubles about making a hobby of astronomy is that telescopes are not cheap. The best way to buy one, unless you have a great deal of money, is to keep a close watch on second-hand 'junk-shops', since it sometimes happens that a good telescope is sold at low cost; but it is important not to buy any telescope until you have had it checked by an expert.

However, you can make a very small refractor by spending only a few shillings. Go to an optician and ask for a spectacle-lens, about 1½ inches in diameter and with a focal length of something like 3 feet. (The focal length of a lens is the distance between the lens itself and the point where the light-rays are brought to focus.) This will serve as our object-glass. Fix it into the end of a cardboard tube, as shown here, using gum and slots; into the other end, fix a smaller tube, just loose enough to be slipped in and out. A smaller lens, of shorter focal length, is then fitted into the other end of the tube to make the eye-piece.



A telescope of this sort should give fairly good results. Of course, it will not be so powerful as a proper instrument, and will probably not be as useful as good binoculars, but it will be much better than nothing.

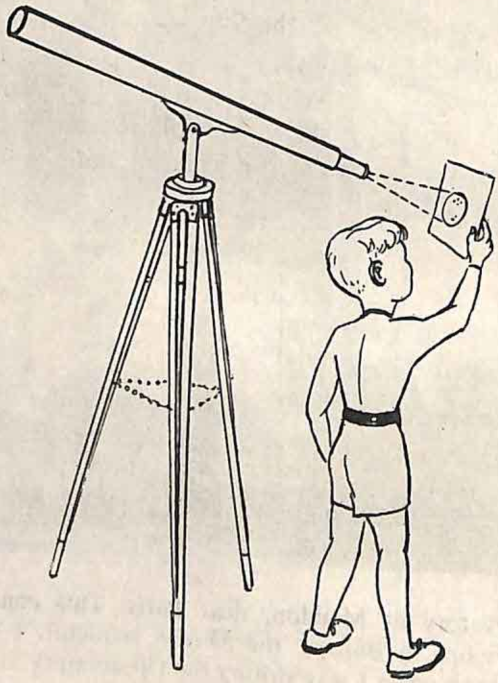
It is important that the telescope should have a stand, no matter how rough. When looking at the Moon, or a star, you will not be able to hold the telescope steady enough unless you have something to rest it on. Making a stand for our spectacle-lens telescope will be easy for anyone who is skilful at carpentry, while a larger instrument is best mounted on a tripod of the kind shown on page 22.

The Observatory at Meudon, near Paris. This contains the largest telescope in Europe, the 33-inch refractor. I took this photograph when I was visiting the Observatory in 1956

The Sun and its Spots

To us, the Sun is the most important body in the sky—and, of course, it can be studied in the daytime, which is convenient if you do not want to stay up late.

There is one rule which must never be forgotten. *Never turn a telescope, or even binoculars, toward the Sun and then look into the eyepiece.* It is dangerous to do so; if you focus the Sun's light and heat on to your eye, you may blind yourself for ever, and it is not

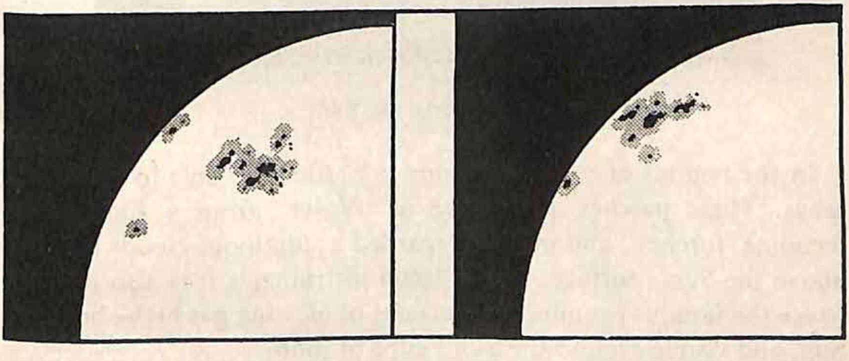


safe to look straight at the Sun even if you put a dark glass over the eye-end of the telescope.

The only sensible way to look at the Sun is to project its image on to a sheet of white paper or card, as the boy in the picture is doing. First point the telescope at the Sun, keeping a tin cap over the object-glass; then take away the cap, and hold the card some inches away from the eyepiece. If you move the telescope to and fro, you will soon find that the Sun's image is visible on the card.

If you are fortunate, you may see one or more groups of sunspots. These are darker patches on the bright surface, and you should be able to make out the darker inner area ('umbra') and the lighter surrounding area ('penumbra') of a large spot. The Sun has a diameter of 864,000 miles, so that the spots are enormous, even though they look so small. A really big spot is many times larger than the Earth.

The spots shift and change, and even the largest does not last for more than a few months. As the Sun is spinning on its axis, completing one turn in about 25 days, you will be able to see the shift of the spots; map them on successive days, and it will be clear that they are moving across the Sun's disk. If you follow a spot-group for long enough, you will be able to watch it as it gradually disappears round the Sun's edge.



Sunspot drawings. The drawings were made on different days, and you can see the apparent shift in position due to the Sun's rotation on its axis.

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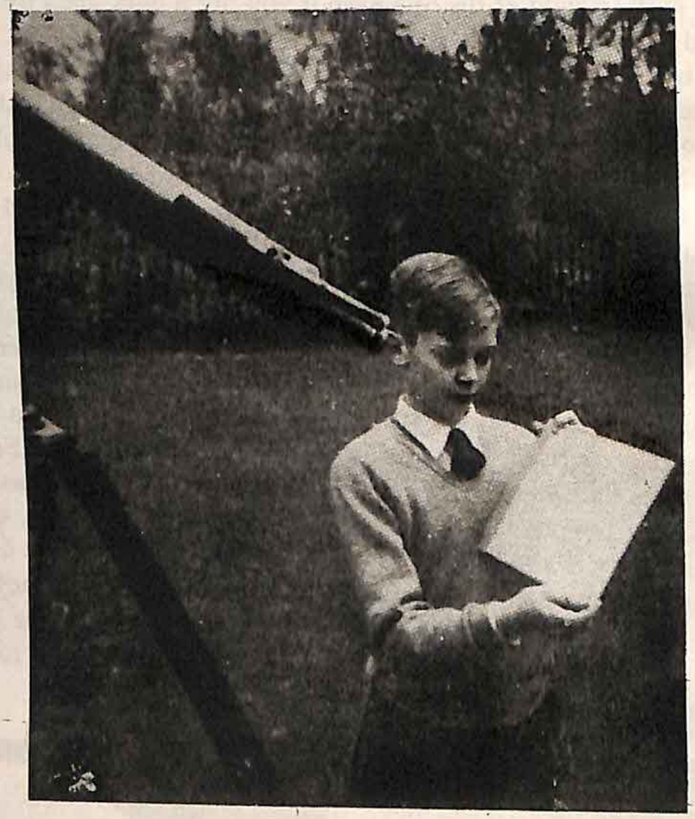
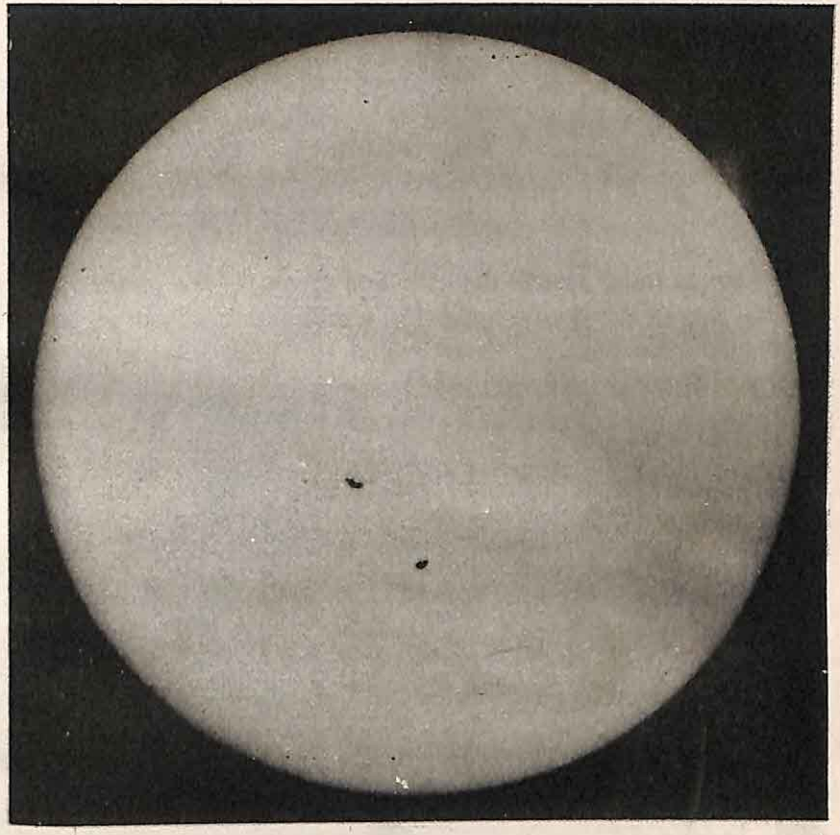


Projecting the Sun

In the regions of sunspot groups it is often possible to see bright areas. These patches are known as 'faculæ', from a Latin word meaning 'torches', and may be regarded as luminous clouds hanging above the Sun's surface. With special instruments it is also possible to see the famous prominences, masses of glowing gas high above the Sun, and visible around the Sun's edge or limb.



Sunspots

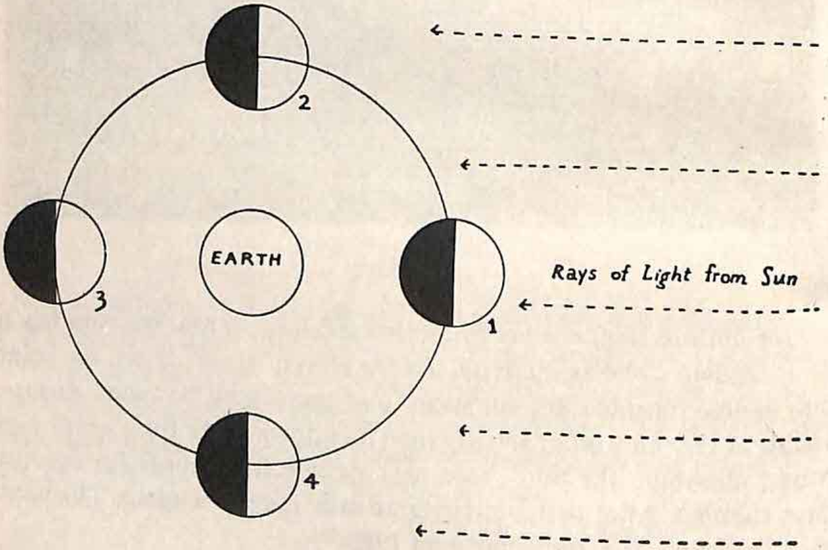
One curious fact, not yet properly explained, is that the Sun has a semi-regular cycle of activity. Every eleven years or so, at solar maximum, sunspots are common, and there may be many groups visible at the same time; activity then dies down, until for a year or so round minimum the Sun's face may be free from spots for several days running. After that, activity gradually increases again. The next spot-maximum is expected around 1969.

The Moon

The Moon is much nearer than the Sun or any of the planets. It lies at a distance of less than a quarter of a million miles from us, so that an airman who flew ten times round the Earth's equator would cover a distance greater than that between the Earth and the Moon.

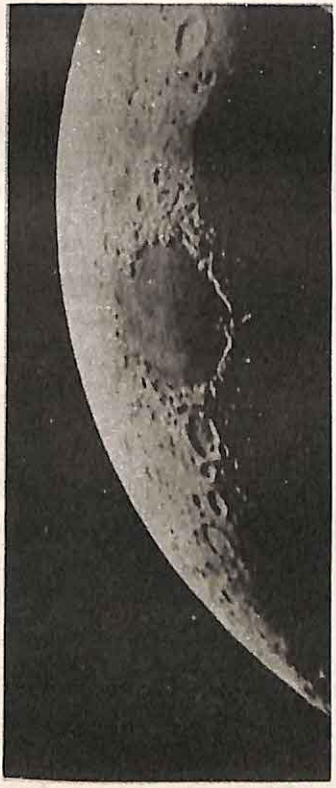
The Moon goes round the Earth once in 27⅓ days. It has no light of its own; it shines by reflecting the light of the Sun, and this is why it shows 'phases', or apparent changes of shape, from new to full.

The Sun can light up half the Moon at any one time, so that it is



'daytime' on one part of the Moon and 'night-time' on the other. The night half of the Moon does not shine, and therefore cannot be seen. In the picture, the night half is blackened.

When the Moon is at position 1, the night half is turned toward us, so that the Moon is 'new' and invisible. As the Moon moves along in its path round the Earth, a little of the day side begins to be turned in our direction, and the Moon shows as a crescent; by the time position 2 is reached, the Moon appears as a half. By position 3, the whole of the day side is facing us, and the Moon is full, after which it changes gradually to a half once more (position 4) and then to a



PART OF THE CRESCENT MOON

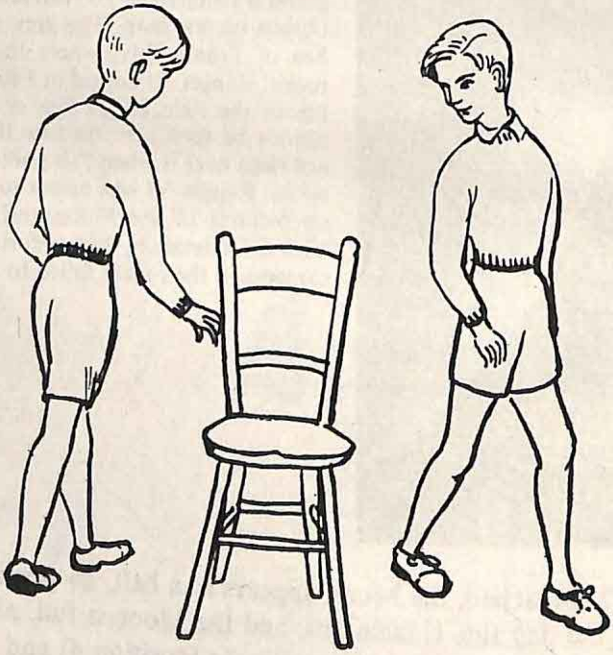
The large darkish plain is the Sea of Crises, and the crater near the top of the photograph is Langrenus; you can find both these objects on the map. The grey plain of the Sea of Tranquillity, where the American rocket Ranger VI landed in February 1964, lies to the right of the Sea of Crises, but cannot be seen here because the Sun had not risen over it when this photograph was taken. Ranger VI was meant to take close-up pictures of the Moon and send them back by television, but unfortunately the cameras in the rocket failed to work.

crescent, becoming narrower and narrower until the next new moon at position 1.

Just as there is moonlight on the Earth, so there is earthlight on the Moon, and it often happens that this earthlight is brilliant enough to make the night side of the Moon shine faintly. It is always interesting to watch for the earthlight appearance when the Moon is a thin crescent.

The Moon is a curious world. It has almost no atmosphere, and no water at all; at noon on its equator, the temperature is greater than that of boiling water, while at lunar midnight a thermometer would show about 250 degrees below zero.

The Moon spins on its axis much more slowly than the Earth, so that a 'day' there is as long as a fortnight here, while the lunar night is equally long. In fact, the Moon makes one turn on its axis for each



revolution round the Earth, so that it keeps the same face toward us all the time. To show this, put a chair in the middle of a room, and then walk round it, turning slowly so as to keep your face turned to the chair all the time. By the time you have been once round, you will have turned once 'on your axis', as shown in the picture; anyone sitting on the chair will never have seen the back of your head, and from the Earth we never see the 'back' of the Moon.

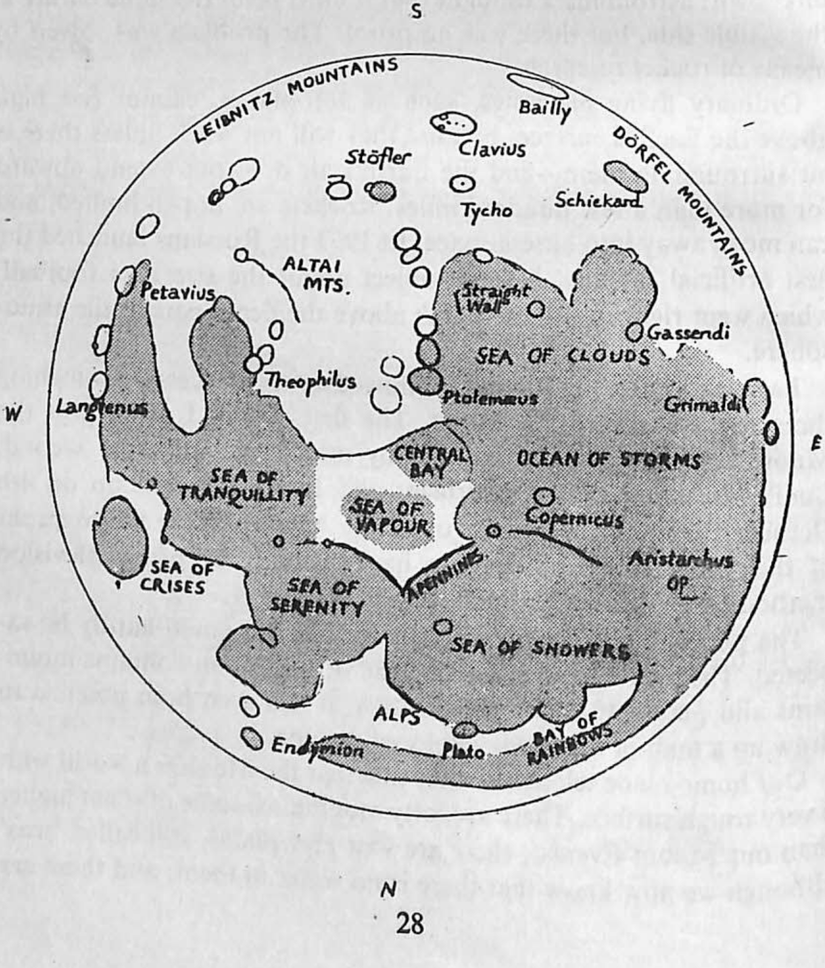
Until 1959, therefore, the other side of the Moon remained quite unknown; astronomers thought that it must be of the same nature as the visible side, but there was no proof. The problem was solved by means of rocket research.

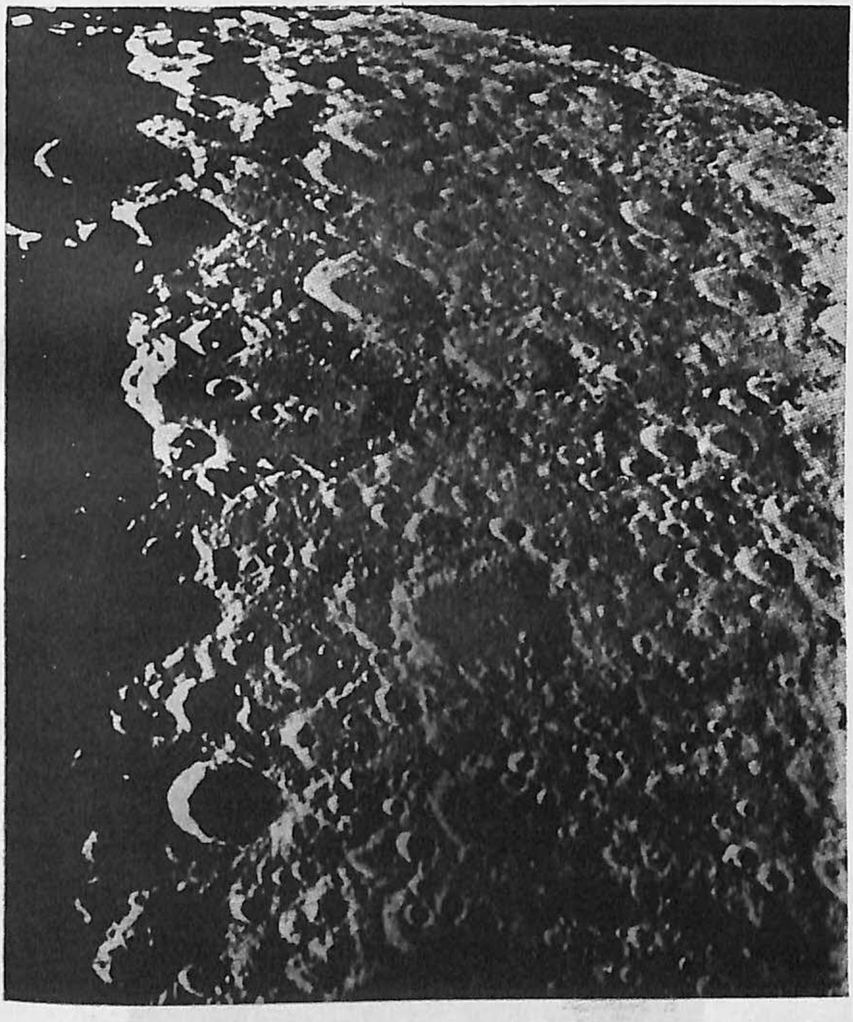
Ordinary flying machines, such as aeroplanes, cannot rise high above the Earth's surface, because they will not work unless there is air surrounding them—and the Earth's air does not extend upward for more than a few hundred miles. Rockets are not so limited, and can move away into airless space. In 1957 the Russians launched the first artificial satellite, a small object about the size of a football, which went right round the Earth above the dense part of the atmosphere.

Two years later, the Russians followed up this success by launching three rockets toward the Moon. The first, Lunik I, went past the Moon, sending back information by means of radio; the second, Lunik II, hit the Moon's surface; and Lunik III, sent up on 4th October 1959, travelled right round the Moon, taking photographs of the 'other side' and sending back pictures by using television methods.

The photographs are not very sharp, but this could hardly be expected. They showed that the far side of the Moon contains mountains and plains, together with craters; it has even been possible to draw up a map of the newly-explored regions.

Our home-made telescope will show that the Moon is a world with a very rough surface. There are lofty mountains, some of them higher than our Mount Everest; there are vast grey plains, still called 'seas' although we now know that there is no water in them; and there are thousands of walled plains known as craters. Some of the craters of the Moon are over 100 miles from side to side, so that they could hold several English counties put together. The largest of all, named Bailly, is almost 180 miles across. The map given here will help you to recognize the main 'seas', mountains and craters. Remember that it is drawn with south at the top, so that if you are using binoculars you will have to turn the map upside-down. The chief seas of the Moon can be seen with the unaided eye.



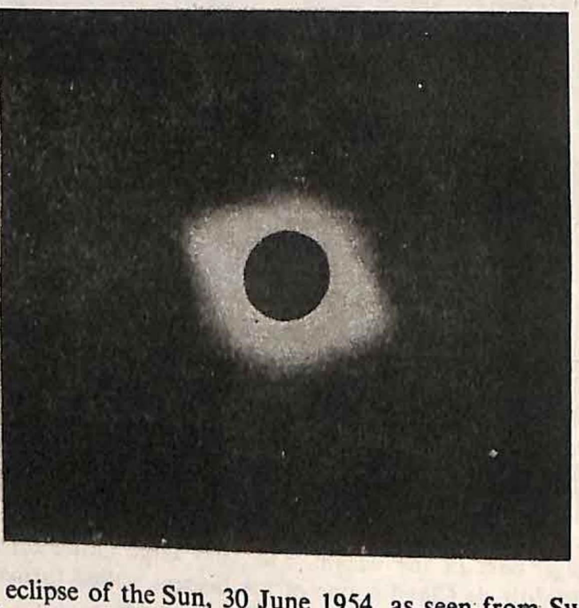


A very rough part of the Moon. The very large crater on the left, just above the middle, is Clavius, one of the biggest walled formations on the Moon—nearly 150 miles across!

Eclipses of the Sun and Moon

By a lucky chance, the Sun and Moon appear almost the same size in the sky; the Sun is much the larger body, but it is also much the more distant. Sometimes the Moon passes in front of the Sun, and hides it, so that we see what is called a 'solar eclipse'. This can happen only at new moon, when the Moon's dark side is turned toward us.

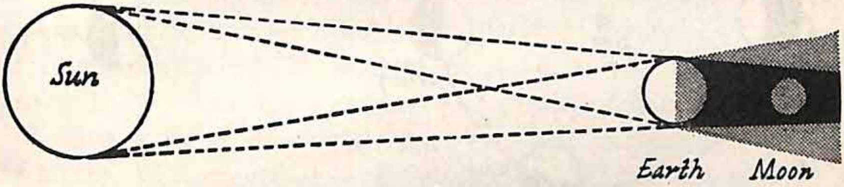
If the Moon does not pass completely across the Sun, the eclipse



Total eclipse of the Sun, 30 June 1954, as seen from Sweden. The dark circle is the Moon; the whiteness around it is the Sun's 'corona', made up of very thin gas is partial, and the appearance is as though the Sun had a piece bitten out of it. When the eclipse is total, the Sun's outer surroundings flash into view, and one can see the pearly Corona, made of very thin gas, and the bright red Prominences. In the usual way, both corona and prominences are overpowered by the bright surface, and cannot be observed at all without the aid of special instruments. Unfortunately, total solar eclipses are rare at any one particular place on the Earth, and the next to be visible from Great Britain will not occur until 1999.

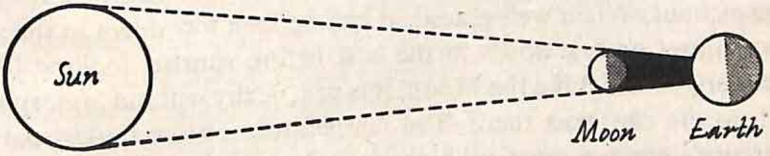
Eclipses of the Moon can also be seen, but are of different type. A lunar eclipse happens when the Moon passes into the shadow cast by the Earth, as shown here. This means that the main sunlight is cut off from the Moon, and the Moon turns a dim, sometimes coppery colour until the eclipse is over.

Lunar eclipses may be either total or partial. They are more commonly seen than eclipses of the Sun, but are not nearly so interesting, though they are well worth watching.



[Not to scale]

Eclipse of the Moon

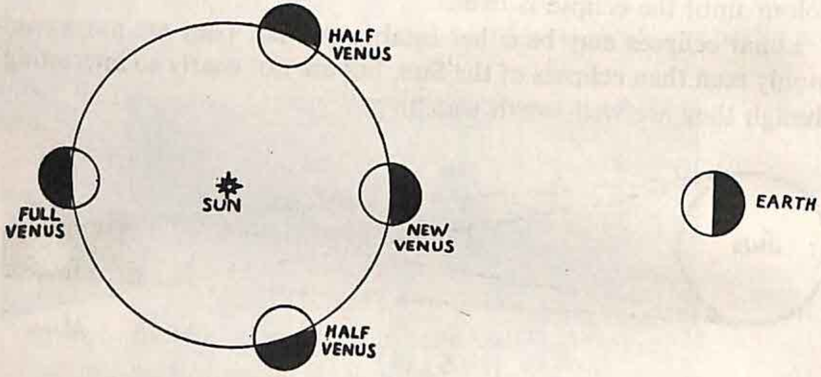


[Not to scale]

Eclipse of the Sun

The Inner Planets, Mercury and Venus

The two planets closest to the Sun are Mercury and Venus. Since they, like the Moon and the other planets, shine only by reflected sunlight, they too show phases from new to full, though these phases cannot be seen without the help of a telescope. The picture shows just how these phases occur.



Mercury is a small world only 3,100 miles in diameter, and it seems to keep fairly near the Sun in the sky, so that it is never very conspicuous. When well placed, it can be seen low down in the west after sunset or low down in the east before sunrise, looking like a fairly bright star. Like the Moon, it is practically without atmosphere, and no life can exist there. The temperature on the hottest part of Mercury's surface must be high enough to melt lead!

Venus is almost as large as the Earth, and sometimes sets as much as five hours after the Sun. It is easy to recognize, because it is much brighter than any other star or planet, and looks like a small lamp in the western sky after sunset or the eastern sky before sunrise.

Venus has always been a mysterious planet. The surface is hidden from us by the planet's atmosphere, and we can see no more than the top of a cloud-layer. Astronomers were able to find out that the atmosphere of Venus was not suitable for Earth-type men or animals to breathe, but until very recently they were not even sure whether the surface was all land or all sea.

Venus is only 67,000,000 miles from the Sun, as against 93,000,000 miles for the Earth, and so would be expected to be a hot world, but measuring the surface temperatures was a difficult matter. Neither did astronomers know the length of the planet's 'day', though they thought that it must be rather longer than the 24-hour 'day' of the Earth.

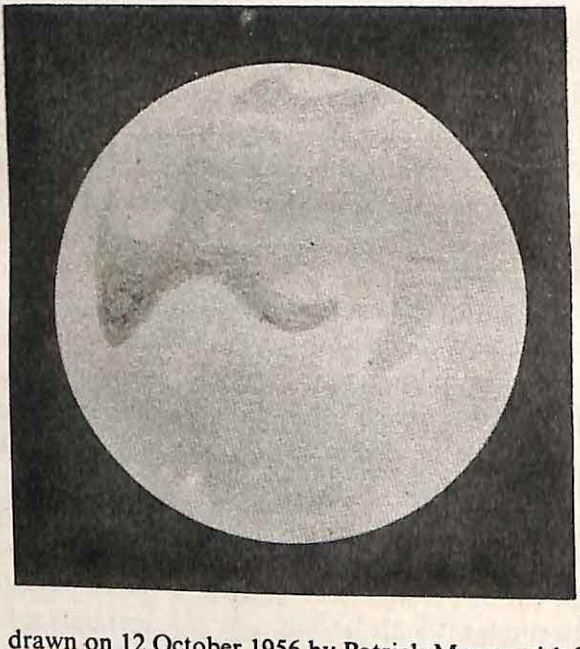
The only way to find out was to send a rocket there, and this was what the American space-researchers decided to do. They therefore launched their rocket, Mariner II, which was designed to pass close to Venus and send back messages to tell us what the planet was like. The experiment was remarkably successful. In December 1962 the Mariner passed within 25,000 miles of Venus, and its radio messages proved to be full of surprises when the scientists studied them.

Instead of being moderately hot, Venus turned out to be really scorching, with a surface temperature of about 800 degrees! This means that no water could exist there, as the water would simply turn into steam. It was also found that instead of being a few weeks long, the 'day' on Venus amounted to several months, and might be about the same as the planet's 'year' of 224.7 Earth-days. Altogether, Venus seemed to be a world quite unsuited to any form of life.

If you look at Venus through a small telescope, you will be able to see the phases, and it is interesting to watch the gradual growth from crescent toward half, and then toward full. You will see little else, but even though Venus is so hostile it is certainly a fascinating world.

Mars, the Red Planet

Of all the planets, Mars is probably the most interesting, because it is the most like our own world. It is smaller than the Earth, and farther from the Sun, so that it is cooler; but a summer day on the Martian equator may be as warm as a spring day in Britain.



Mars, drawn on 12 October 1956 by Patrick Moore with his 12½-inch reflector. You can see the white polar cap, and the dark areas believed by many astronomers to be due to vegetation

At its closest to us, Mars approaches the Earth to within 35 million miles, and is then nearer than any other large body apart from the Moon and Venus. At these times it is easy to recognize, because it is not only very brilliant but also very red. It becomes conspicuous for a few months every alternate year.

When Mars is well placed, a small telescope will show markings. The polar regions are whitish, because they are covered with a thin icy deposit; there are also dark areas, which are generally thought to be due to low-type plants, though some astronomers doubt this. The rest of the surface is reddish, and it may be said that much of Mars is desert. However, a Martian desert is not a sandy waste such as the Sahara; it is chilly, and the surface coating is more like 'dust' than sand.

It used to be thought that men lived on Mars, and that the strange streaks drawn by some astronomers were artificial canals, but nowadays it is believed that Mars is uninhabited. There is an atmosphere, but no men or animals could possibly breathe it.

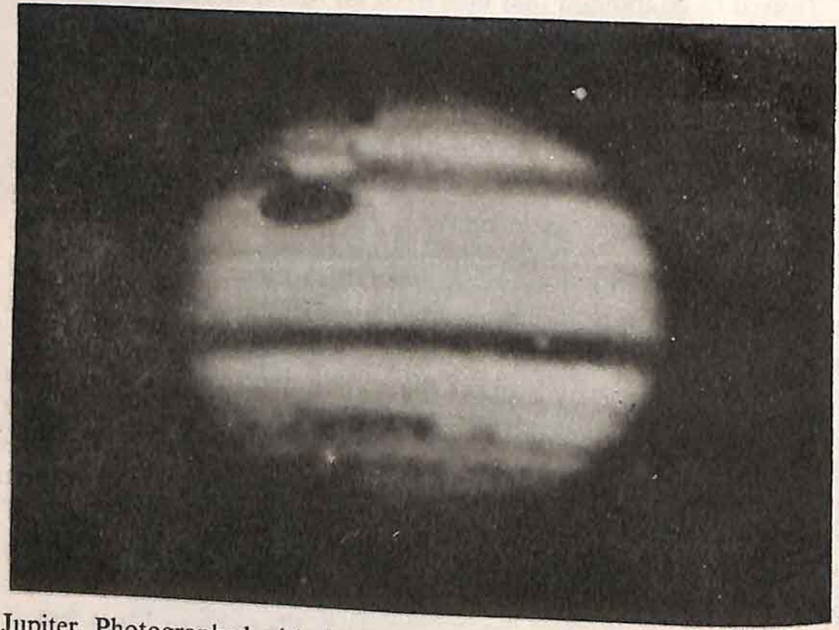
We have only one moon, but Mars has two, Phobos and Deimos. Both are very small, and can only be seen with the help of a large telescope. Phobos is so close to Mars that it revolves round the planet in only 7½ hours. As Mars takes 24½ hours to turn on its axis, the 'month', so far as Phobos is concerned, is shorter than the 'day'; and to an observer on Mars, Phobos would seem to rise in the west and set in the east!

Mars is farther away from us than Venus, and never comes much within 35,000,000 miles of the Earth. To send a rocket there is a very difficult matter, but in 1962 the Russians made an attempt. Unfortunately the experiment was not a success, and the rocket did not pass close to Mars; its radio failed, too, so that the Russians lost track of it. However, new Mars-rockets will probably be sent up within the next few years.

We cannot tell if and when men will be able to go to Mars, but at all events we may be fairly sure that Mars is a much less unfriendly world than either Venus or the Moon.

Jupiter, the Giant Planet

Beyond Mars we find several thousands of very small worlds, known as Minor Planets or Asteroids. Even the largest of them, Ceres, is less than 500 miles in diameter, while only one (Vesta) can ever be seen without a telescope.



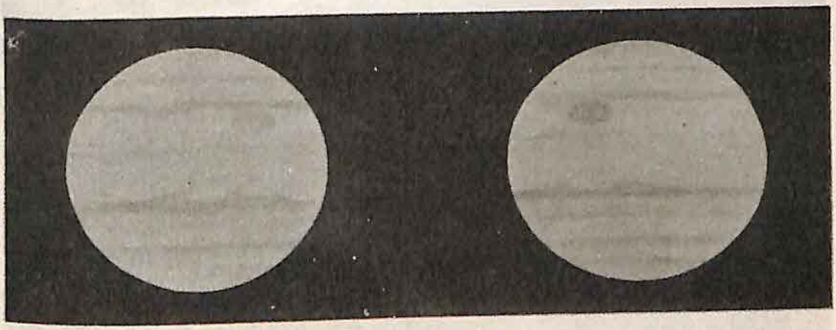
Jupiter. Photographed with the 200-inch Palomar telescope. You can see the belts and the Great Red Spot. The white disk to the upper right of Jupiter is Jupiter's brightest moon, Ganymede, and the black circle near the top of Jupiter is the shadow cast by Ganymede on to the planet

Next comes Jupiter, largest of all the planets. Its vast globe is big enough to hold 1,300 bodies the size of the Earth, but it is not solid and rocky; its surface is made up of dense, poisonous gas, and it is so far from the Sun that it is bitterly cold.

Our home-made telescope will show that Jupiter's yellowish disk is crossed by straight bands or 'belts'. There are also 'spots', one of which, the Great Red Spot, has lasted for hundreds of years, though it is not always conspicuous and is not truly red. If you are using a telescope powerful enough to show details on the belts, you will see that the markings are drifting slowly across the disk, as is shown in the picture. This is because Jupiter spins quickly on its axis; the 'day' there is only 9¾ hours, though the 'year' is over eleven times as long as ours.

Jupiter has twelve moons. Eight are very faint, but four are bright enough to be seen with any small telescope, and if you watch them from night to night you will be able to follow their movements as they revolve round Jupiter.

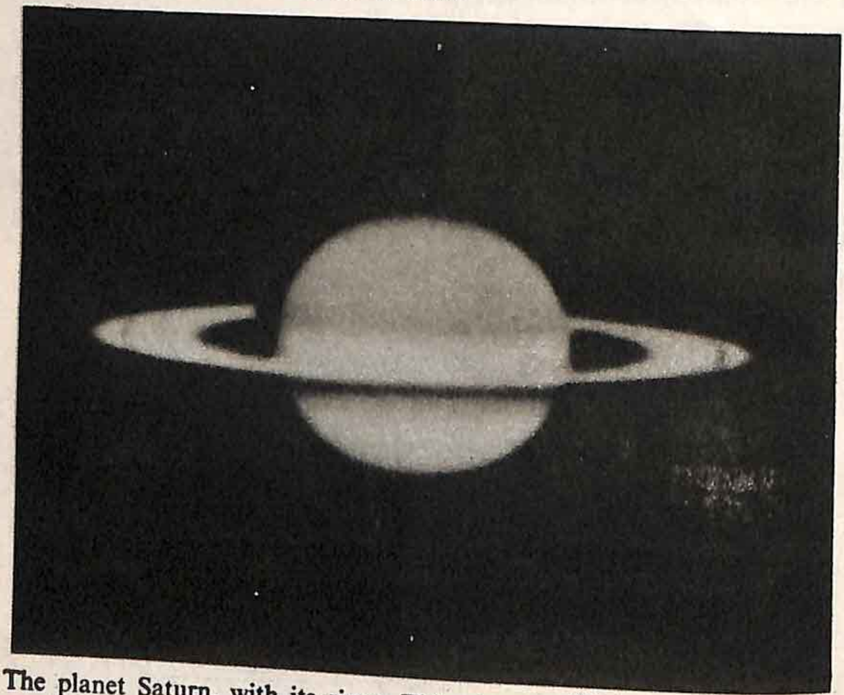
Jupiter is easy to recognize, because it is so brilliant. In colour it is white or slightly yellowish, and it can be well seen for several months in each year.



Drawings of Jupiter, made on 22 March 1957. Note the obvious shift in the position of the Great Red Spot, due to Jupiter's rapid rotation on its axis

Saturn, the Planet with the Rings

Saturn, the second of the giant planets, is not so large as Jupiter. It is also much farther from the Sun and the Earth, so that it appears fainter; it looks like a yellowish star, and is not easy to recognize unless you know where to look for it.



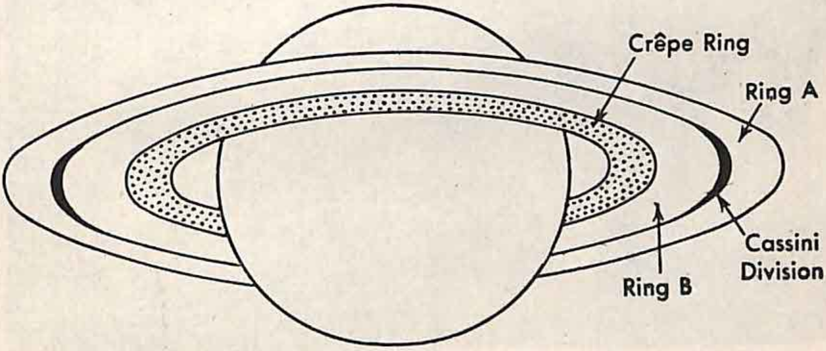
The planet Saturn, with its rings. This photograph was taken with the world's largest telescope; but your own 3-inch telescope will show the rings well

Like Jupiter, it is not a solid, rocky body, but has a surface made up of gas. It is even colder than Jupiter, and it is clear that no life can exist there. There are belts, and occasional spots, but a telescope of fair size is needed to show them properly.

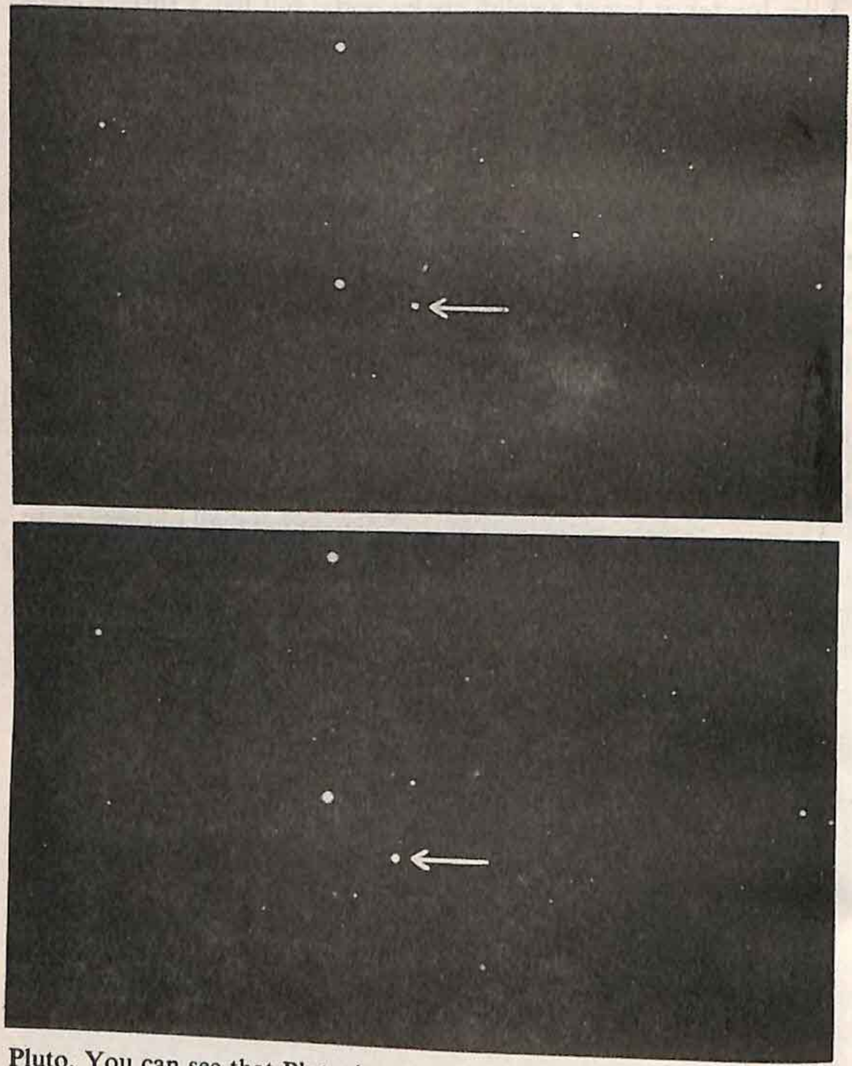
Saturn is a glorious object, because it is surrounded by a system of rings unlike anything else in the sky. There are two bright rings, separated by a gap known as Cassini's Division, and one fainter, transparent ring. A small instrument will show the ring system quite well, and a refractor with a 3-inch object-glass should be powerful enough to show Cassini's Division when the rings are suitably tilted.

The rings are not solid or liquid sheets, but are made up of thousands upon thousands of little pieces of matter, whirling round Saturn like miniature moons. In addition, Saturn has nine true moons, one of which (Titan) can be seen with a very small telescope.

There are three more planets in the Solar System, all of them more distant than Saturn. Uranus and Neptune are giants, Pluto a peculiar little body smaller than the Earth. Uranus can just be seen with the unaided eye, but Neptune and Pluto are invisible without a telescope.



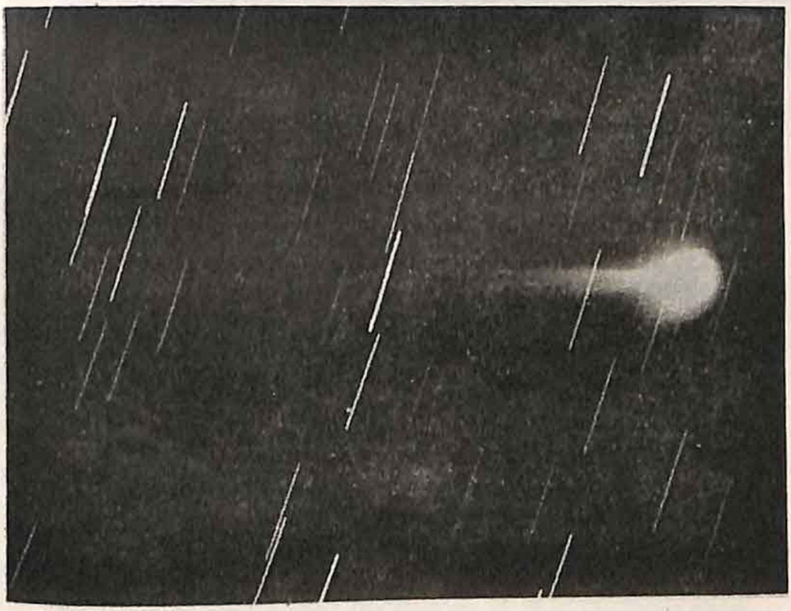
It is quite possible that still another planet exists, more distant than Pluto; but even if so, it will be so faint that it will be very difficult to find.



Pluto. You can see that Pluto (marked by the arrow) moved between the times at which the two photographs were taken. These photographs were taken with the 200-inch reflector at Palomar. Pluto is so faint that a telescope of fair size is needed to show it at all

Comets and Shooting Stars

Most people have heard of comets, and picture them as brilliant objects with long tails. It is true that some comets do look like this, but many others are faint and tail-less, so that they seem more like puffs of luminous cotton-wool in the sky.

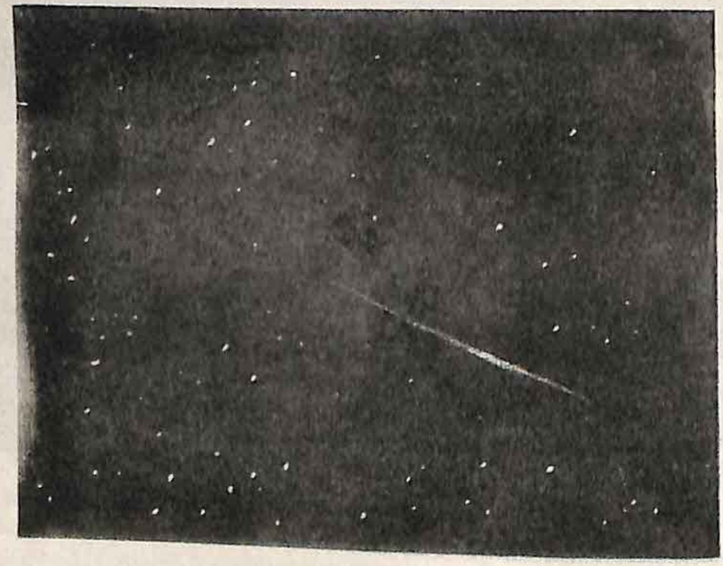


Comet Cunningham which had a fan-shaped tail. The comet was moving slowly against the stars and since the camera had to 'follow' the comet, the stars are drawn out into the streaks of light. Of course, the comet's motion was too slow to be noticed except by measuring it

Comets are not solid bodies, but are made up of relatively small pieces of matter contained in a 'cloud' of thin gas. Though they were once believed to be unlucky, it is now known that they are completely harmless.

Some comets revolve round the Sun in elliptical paths; the most famous of these is Halley's Comet, which has a period of 76 years, and will next become brilliant in 1986. Most of the bright comets, however, have periods of many hundreds or even thousands of years.

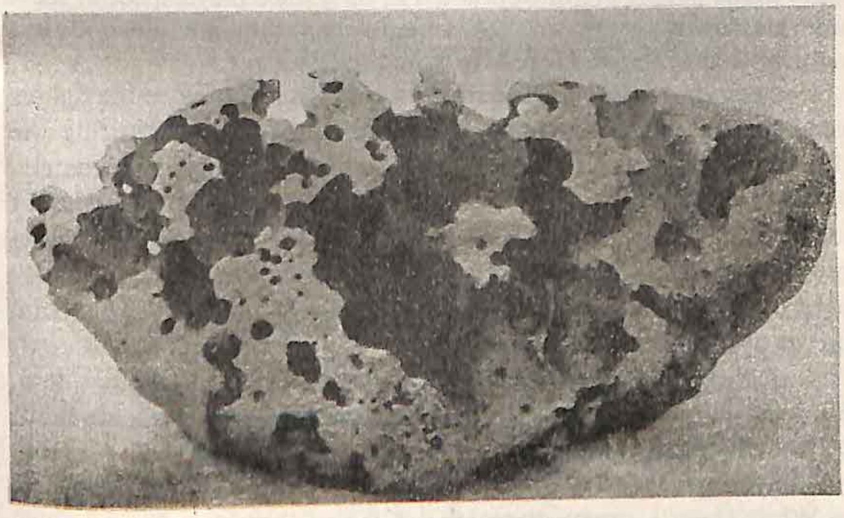
Meteors, or shooting-stars, are small pieces of matter revolving round the Sun like dwarf planets. Out in space they can move freely, but if a meteor happens to come too close to the Earth, and is moving at the right speed in the right direction, it approaches the ground, and dashes into the air. When this happens, it has to push the air out of its way; friction is set up, and this causes heat, so that the meteor burns away in the streak of fire which we call a shooting-star. When



A shooting star

the Earth plunges through a swarm of meteors, we see a shower of shooting-stars. Many showers occur each year, but the most famous is that of the first fortnight of August, so that this is the best time to watch for meteors.

Nearly all meteors are tiny bodies smaller than grains of sand, but if the Earth happens to meet a larger object it is possible for the body to fall to the ground without being burned completely away. Those that survive the drop are called 'meteorites'. Occasionally we encounter a really large meteorite; one which fell in Siberia in the year 1908 blew trees flat for miles around the point of impact.



A large meteorite. This one weighed many tons, but most 'shooting-stars' are caused by bodies no larger than grains of sand

A meteorite is quite different from an ordinary 'shooting-star' meteor, and is more nearly related to the minor planets or asteroids. Most museums have collections of small meteorites—there is a good collection, for instance, in the museum at South Kensington—but large falls are very rare, and there is no known case of anyone having been killed by a plunging meteorite.

The Stars

When we turn a telescope toward a planet, we can see a definite disk; on some of the planets (particularly Jupiter) there are obvious markings. But no telescope will show a star as anything but a point of light. Some people are disappointed at this, since they expect to see a star magnified to the size of a tennis-ball, but we must always remember that the stars are a very long way away.

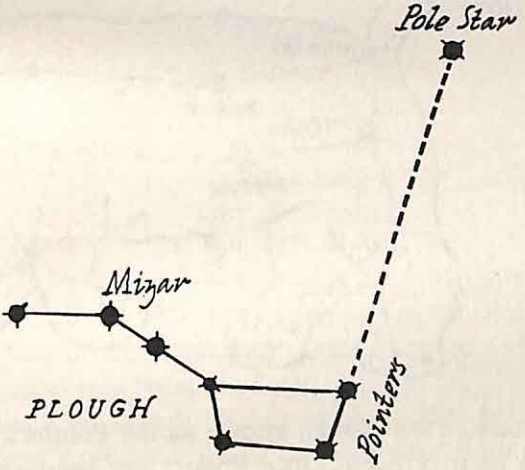
It is not convenient to give star-distances in miles, since the figures needed would be so large—it would be rather like measuring the distance between London and Manchester in inches. Fortunately, we have a better unit. Light travels at 186,000 miles per second, and a ray of light will therefore cover rather less than 6 million million miles each year. This distance is called the 'light-year', and is widely used by astronomers. The nearest star, apart of course from the Sun, lies at a distance of 4⅓ light-years.

Though the stars are suns, they are not all similar to our own Sun. Some are far hotter, so that they shine with a white or bluish light; others are cooler, so that they appear red. There are giant stars immensely larger than the Sun, while others, such as the bodies known as White Dwarfs, are much smaller. A few of these dwarfs are known to be smaller than the Earth, though they are much more massive, and are quite unlike planets.

The stars are moving at great speeds, but are so distant that it takes many years for their individual movements to become noticeable; therefore the star-groups or 'constellations' remain unaltered year after year. As we know, the daily rising and setting of the stars is due purely to the Earth's rotation, and has nothing to do with the stars themselves.

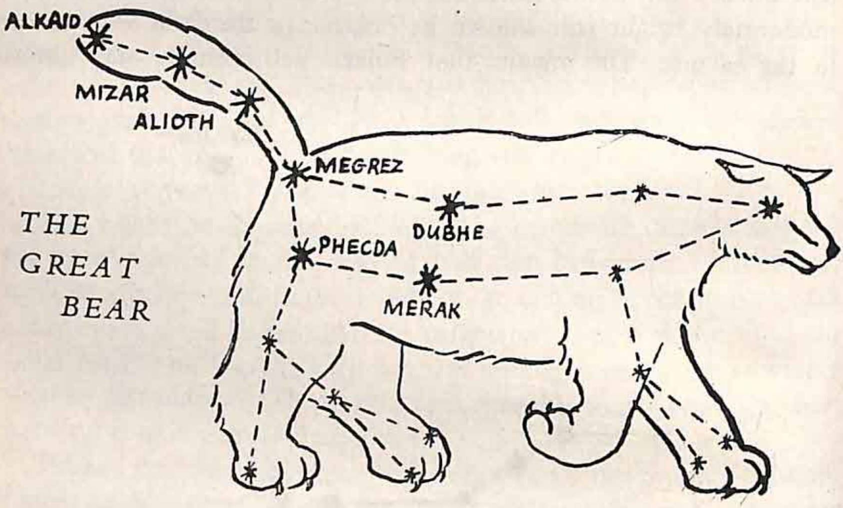
The Northern Stars

The Earth's axis points northward to a position almost marked by a moderately bright star known as Polaris, or the Pole Star, shown in the picture. This means that Polaris will seem to stay almost still, while everything else in the sky appears to revolve round it. In Britain, Polaris is always above the horizon; from places south of the equator it is always below the horizon, and so cannot be seen at all. There is no brilliant star close to the south pole of the sky.



Stars close to Polaris do not set in Britain, but merely sweep round Polaris in circles, always remaining visible. The most famous of these northern groups is the Great Bear, whose seven chief stars mark the Plough.

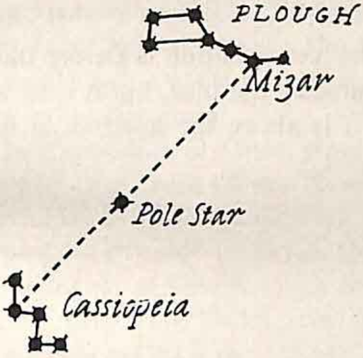
You will enjoy star-watching much more as soon as you know your way around the sky, and the best way to learn the different groups is to use a few bright constellations as 'signposts'. The Plough is very useful, because it can always be found. At its lowest, as in November and December evenings, it is between Polaris and the northern horizon, while when highest, as in late evenings in April, it is overhead.



The two stars of the Plough known as the Pointers, shown in the picture, lead us to Polaris. Once Polaris has been recognized, you will always be able to find it again. Stand in a known position—by a particular post in a fence, for instance—and then note the position of Polaris compared with, say, the chimney of a nearby house. As Polaris is almost motionless, it will always keep in the same place relative to the chimney.

Another constellation which never sets in Britain is Cassiopeia, the Lady in the Chair. An easy way to find it is to draw an imaginary line from the second star in the Plough handle (Mizar) through Polaris, and continue for about the same distance beyond Polaris. Cassiopeia is marked by five rather bright stars arranged in the form of a rough W.

As soon as you have recognized a constellation, it is a good idea to make a quick map of it, noting down any particularly bright stars. If you do this, you will remember the pattern, and you will easily identify the constellation again on a future night.



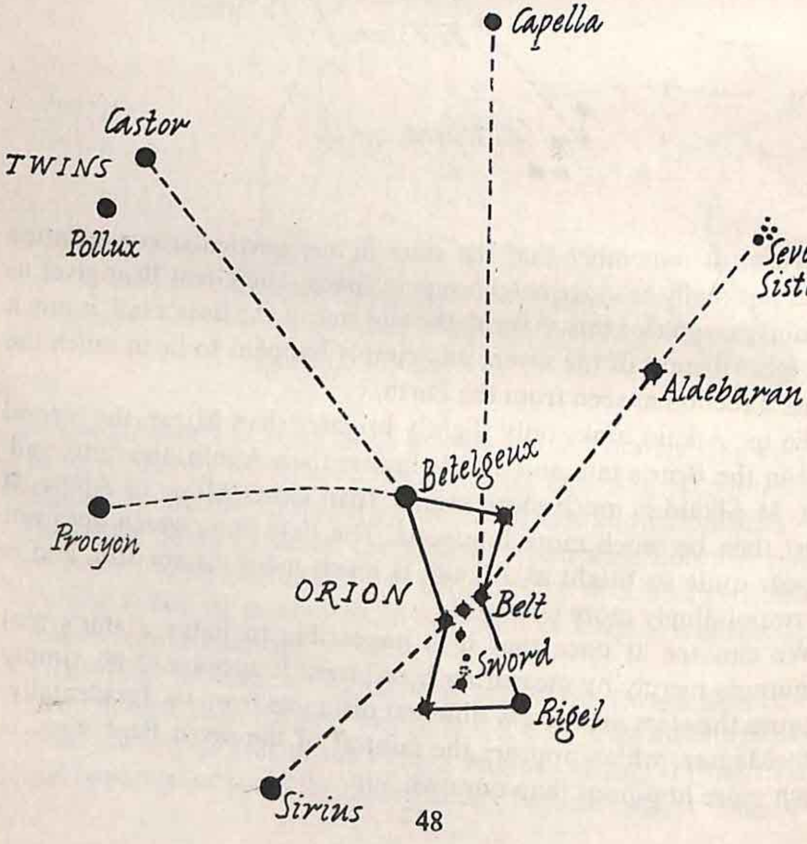
We must remember that the stars in any particular constellation need not really be close neighbours in space. The Great Bear gives us a good example of this. Alkaid, the end star in the Bear's tail, is much the most distant of the seven, and simply happens to lie in much the same direction as seen from the Earth.

To us, Alkaid looks only slightly brighter than Mizar, the second star in the Bear's tail, and a little fainter than Alioth, the third 'tail' star. If Alkaid is much more remote than either Mizar or Alioth, it must then be much more luminous. The Pole Star, which does not appear quite so bright as Alkaid, is much more distant still, and is correspondingly more powerful.

We can see at once that it is impossible to judge a star's real brightness merely by measuring how bright it appears to be, simply because the stars are at very different distances from us. Incidentally, even Megrez, which appears the faintest of the seven Bear stars, is much more luminous than our own Sun.

The Stars of Winter

The second 'signpost' constellation is Orion, the Hunter. Unlike the Plough, it is not visible all the time, but it is so well marked that it is easy to find when it is above the horizon. It is conspicuous in the



evenings during the late winter and through most of the spring; at eight o'clock on February 1st, for instance, you will see it fairly high up in the south.

The stars of Orion are brighter than those of the Plough, and two of them, Betelgeux and Rigel, are among the brightest stars in the whole sky. They differ in colour; a glance will show that Betelgeux is reddish, while Rigel is bluish-white. Rigel is a particularly luminous star, and shines far more brilliantly than the Sun. According to a recent estimate, it would take 50,000 suns to equal Rigel, though of course this value is rather uncertain.

The three stars in the middle of Orion form the Hunter's 'Belt', while below the Belt lies the much fainter 'Sword'. This picture will help you to find Orion without any difficulty.

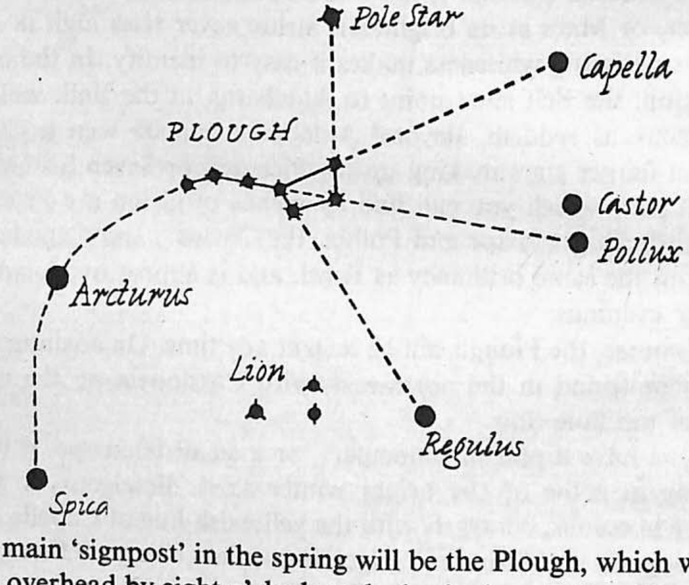
The Belt stars point downwards to Sirius, the most brilliant star in the heavens (though it is of course much fainter than Venus or Jupiter, or Mars at its brightest). Sirius never rises high in Britain, but its glittering whiteness makes it easy to identify. In the opposite direction, the Belt stars point to Aldebaran in the Bull, which, like Betelgeux, is reddish. Beyond Aldebaran can be seen a cluster of several fainter stars making up the Pleiades, or Seven Sisters. Other bright stars which you can find by means of Orion are Procyon, in the Little Dog; Castor and Pollux, the 'Twins'; and Capella, which is about the same brilliancy as Rigel, and is almost overhead during winter evenings.

Of course, the Plough can be seen at any time. On a winter evening it can be found in the north-east, with Cassiopeia on the opposite side of the Pole Star.

If you have a pair of binoculars, or a small telescope, it is worth looking at some of the bright winter stars. Betelgeux, a glorious orange in colour, contrasts with the yellowish hue of Capella and the glittering white of Sirius and Rigel. Binoculars bring out these various colours very strongly.

The Stars of Spring

By spring, the evening sky has become less splendid than was the case in winter—unless, of course, some of the brilliant planets are visible. If we observe at, for instance, eight o'clock in mid-April, Orion will be setting, though Procyon, the Twins and Capella will still be conspicuous. Capella, indeed, never sets in Britain, though at its lowest point it almost touches the horizon.



Our main 'signpost' in the spring will be the Plough, which will be almost overhead by eight o'clock at the beginning of May. The curve of the Plough handle leads us to a very brilliant star, Arcturus, which is actually the brightest star visible from Britain, apart from Sirius.

It can be recognized by its pale orange colour, very different from the yellowish hue of Capella or the whiteness of Rigel. Arcturus will remain conspicuous in the evening sky all through the summer. If we carry our curved line still farther, we shall come to the white star Spica, much fainter than Arcturus, but still bright enough to be easily recognized. Spica is the chief star of the constellation of the Virgin; it is really much more luminous than Arcturus, but seems fainter because it is further away.

Yet another important group is the Lion, which is to be seen in the south, and can be found by using the 'signpost' of the Plough. Its chief star, Regulus, is almost as bright as Spica, while between Regulus and Spica we can see a rather conspicuous triangle of stars.

We can also use the Plough to help us find the Twins, Castor and Pollux, which are still above the horizon. Between the Twins and Regulus lies a faint constellation, the Crab, which includes an interesting cluster of stars known as Præsepe, or the Beehive.

It is not difficult to see why Præsepe has been nicknamed the Beehive, because it is made up of large numbers of faint stars apparently crowded together (though in reality, of course, they are a long way away from each other). On the other hand, nobody can possibly make a lion out of Leo, the bright constellation which includes Regulus, and the stars of the Crab certainly do not form a pattern in the least like a crab.

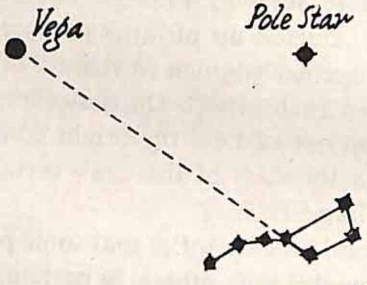
Spring is also a good time to notice that some parts of the sky seem to be much more crowded than others. In particular, look at the large area enclosed by the Plough, Capella, Regulus and the Twins. This space is occupied by the constellation of the Lynx, which contains no bright stars at all.

Next look at the area enclosed by Arcturus, Spica and Regulus. This time you will see quite a number of bright stars, and large numbers of fainter ones. If you start counting the stars visible in this part of the sky, you will find that it will take you a very long time indeed.

The Stars of Summer

Summer is the worst time for star-gazing, because the sky does not darken until very late; when the Moon is near full, there is no real 'darkness' at all.

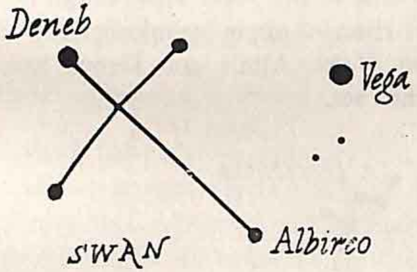
If we look up as soon as the stars become visible upon an evening in July or August, we shall find that Orion and its brilliant companions have disappeared—apart from Capella, which can still be observed very low in the north. The Plough lies in the north-west, and Cassiopeia in the north-east, while Arcturus is still conspicuous.

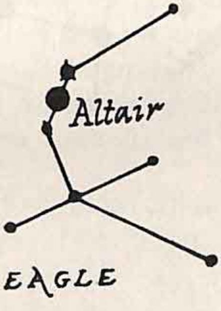


As we know, Capella is almost overhead during evenings in the late winter. On a summer evening, the overhead position is taken by an even brighter star, Vega, in the little constellation of the Lyre. Vega is distinctly blue, and in a low-power telescope, or a pair of binoculars, it is a wonderful sight.

Forming a triangle with Vega are two other bright stars, Altair in the Eagle and Deneb in the Swan. Altair can be recognized because it has a fainter star to either side of it; Deneb is not so prominent, though it is really an extremely luminous star lying at a great distance from us. The Swan itself can be found easily, as its leading stars are arranged in the form of a cross, with the faintest star of the cross (Albireo) lying more or less between Vega and Altair.

During late evenings in June and July, look for a bright red star low down in the south. This is Antares, in the Scorpion. Its colour makes it easy to identify, and its name means 'Rival of Mars'. Like Altair, it has a fainter star to either side of it.

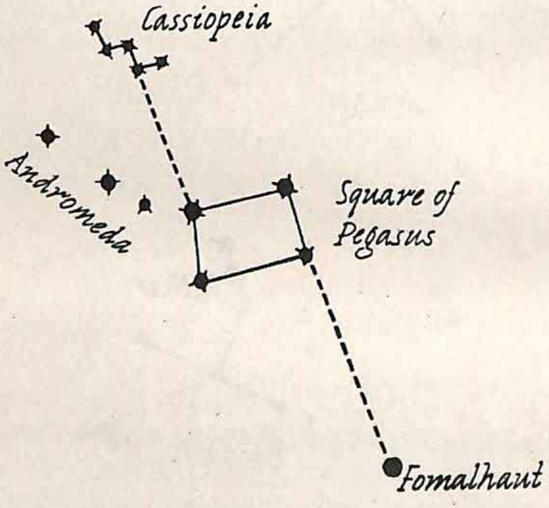




The Scorpion is a splendid constellation; it is made up of a long line of stars, of which Antares is the most brilliant, and we can see why the ancient astronomers gave it its name. Unfortunately it is always too low to be well seen in Britain, and the southernmost part of it never rises at all.

The Stars of Autumn

The night-sky on an autumn evening is, perhaps, less interesting than at any other time in the year. The Plough is low in the north; Orion has not yet risen, though by midnight in October it is well above the horizon. Vega, Altair and Deneb are all conspicuous, though Arcturus has set.



One of the more important groups of autumn is Pegasus, the Flying Horse, whose four chief stars form a square. On maps, the Square looks smaller and brighter than it really is, but it can be found without difficulty if you can identify Cassiopeia, since two of the stars of the W point toward it. Leading from the Square in the direction of Capella is a line of stars marking Andromeda, the Chained Lady, while between Andromeda and Capella is the rich constellation of Perseus, the Hero.

Once Pegasus has been found, you can pick out Fomalhaut, a bright white star which never rises far above the horizon in Britain. It lies in the small constellation of the Southern Fish, and is quite prominent during September and October evenings.

The Southern Stars

If you travel southward, towards the equator, you will be able to see many new stars and star-groups which never rise above the horizon in Britain. It is a pity that they are invisible from our latitudes, because some of them are both brilliant and interesting.

The most famous of these constellations is the Southern Cross. It does not look very much like a cross, and 'the Southern Kite' would be a better name for it, but its four chief stars are exceptionally close together, and are bright enough to make the group very conspicuous. The Southern Cross is as familiar to Australians or New Zealanders as the Great Bear is to us—and from Australia and New Zealand, the Cross never sets.

Even more prominent, perhaps, is the glorious yellow star Canopus, in the constellation of the Ship. Apart from Sirius, it is the most brilliant star in the whole sky. Moreover, it is very distant and highly luminous; according to one estimate, it shines as brightly as 80,000 suns put together.

Another prominent southern group is the Centaur. In old legends, a centaur was a strange creature with a man's head and a horse's body. The Centaur in the sky contains two exceptionally bright stars which show the way to the Southern Cross.

Different Kinds of Stars

Though the stars are so remote that no telescope will show them as anything but points of light, they are not all alike. As we have seen, they differ in colour; moreover, some of them are of special interest.

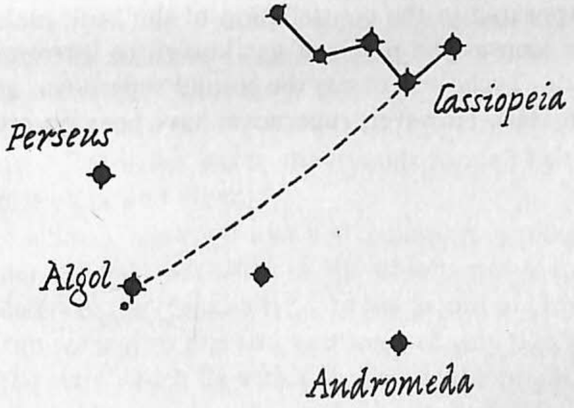
For instance, there are some stars which are double. The most famous of these is Mizar, the second star in the handle of the Plough. On a fairly clear night, anyone with normal eyes can see a much fainter star, Alcor, close to it; when a telescope is used, we can see that Mizar itself is double, while between it and Alcor lies a still fainter star.

Some double stars are due to line-of-sight effects, so that one of the pair is much closer to us than the other—just as two widely-separated trees will look close together if you stand in line with them, some distance away. In other cases, however, the two stars of a pair are real 'partners', revolving round each other much as the two bells of a dumb-bell revolve when the joining bar is twisted. A system of this sort is known as a 'binary'. Castor, in the Twins, is one such binary, as you can see if you look at it with a telescope.

It sometimes happens that one star of a pair is much brighter than the other. This is the case with Albireo, the faintest star in the cross of the Swan. Albireo is probably the loveliest double in the sky; a small instrument shows that it is made up of a yellow star with a much dimmer green companion. Even more interesting is the remarkable object Epsilon Lyræ, near Vega. Here we have a double star, each star of which is again double—so that we have a 'double-double' system. A 3-inch refracting telescope will show it well.

Most of the stars seem to shine steadily, and do not alter in brilliancy, but there are some which brighten and fade. One of these Variable Stars is Betelgeux in Orion. Usually it is about equal to Aldebaran, but at timsə it may rival Rigel, while at others it is no brighter than Pollux. Its changes are very slow, but they are interesting to follow.

Variable stars are of different types; some have regular periods, while others are irregular. Algol, the 'Demon Star' in Perseus, is a star which changes in brightness, but is not truly 'variable' at all. It is the brighter member of a binary system, and when the fainter



member passes in front of the brighter star the total light sent to us is reduced. Algol can be found by using the W of Cassiopeia as a 'signpost', as shown. Generally it is about equal to the brightest star of the W; but when the fainter body is passing in front of it, Algol looks no brighter than the faintest of the seven stars of the Plough.

Occasionally, a very faint star may flare up to great brilliancy, and remain conspicuous for a few days or a few weeks. These new stars or 'Novæ' are very interesting, but the last nova to be really prominent as seen from Britain occurred as long ago as 1936.

In the year 1572, a Danish astronomer named Tycho suddenly noticed a brilliant new star in the constellation of Cassiopeia. During the next few days it brightened up until it outshone even Venus, and could be seen in broad daylight, but then it faded away until it had been lost to view.

We now know that Tycho's star was not an ordinary nova, but a 'supernova'—an even more tremendous outburst, in which the star literally exploded and scattered its material away into space. When at its brightest, it shone with millions of times the luminosity of our Sun.

Only three such supernovæ have been observed in our own star-system. One was seen in 1054, during the reign of Edward the Confessor; it appeared in the constellation of the Bull; and its remains can still be seen as the patch of gas known to astronomers as the Crab Nebula. Tycho's Star was the second supernova, and the third was seen in 1604. However, supernovæ have been observed in other galaxies.

Star-Clusters and Nebulæ

One of the most interesting objects of the winter sky is the cluster of stars known as the Pleiades. It is so conspicuous that it has been known since very early times, and once you have recognized it you will never forget it.

An old name for the cluster was the Seven Sisters, since it was said that seven stars could be seen in it without the help of a telescope. Actually, anyone with normal eyes should be able to see eight or nine when the sky is really clear, and it is interesting to see how many 'sisters' you can count. The record is, apparently, held by a last-century German astronomer, Heis, who could glimpse nineteen. Binoculars show many more, and even a small telescope will reveal several dozens of separate stars. The cluster is a real system, not just a line-of-sight effect.

Many other clusters are known, some of which can be seen with the unaided eye. The Hyades, round Aldebaran, are arranged in a rough V, but are less beautiful than the Pleiades because they are more scattered. Præsepe, in the Crab, has been called the Beehive, and, as we have mentioned earlier, appears as a dim glow on a moonless night; it lies inside the triangle formed by the bright stars Procyon, Pollux and Regulus.

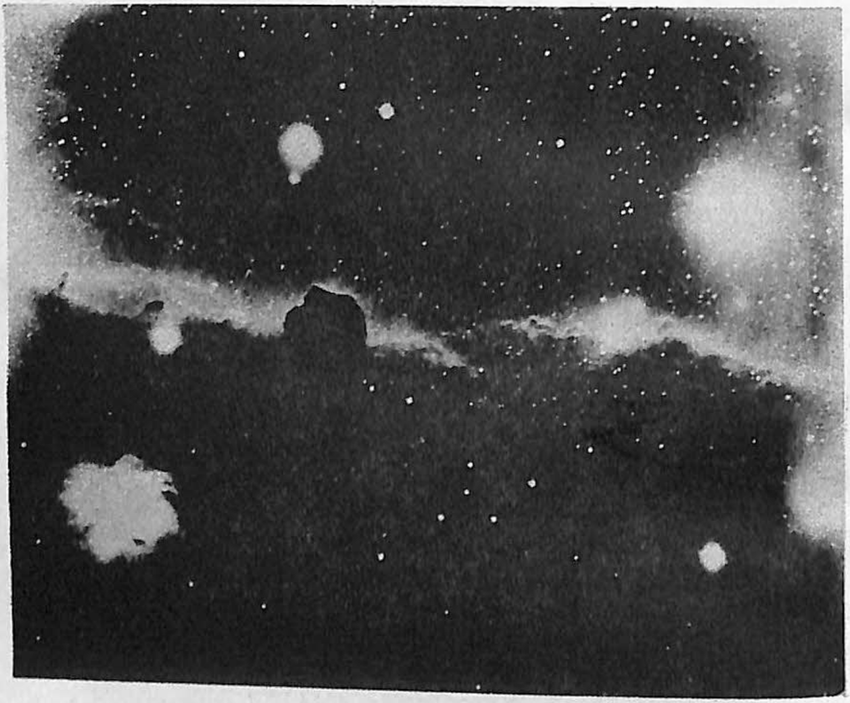
If you have a small telescope and a star-map, it is interesting to search for other clusters, but some of the objects prove to be quite unlike true clusters of the Pleiades type. In the Sword of Orion, below the Belt, you can see a glow due to a vast mass of very thin gas, made luminous by the stars which lie within it. This is the brightest of the 'nebulæ', a name which comes from the Latin word for 'clouds'.

Our home-made instrument will show a number of the stars contained in it, and the sight is a wonderful one. Many thousands of these nebulæ are known.

The Pleiades or 'Seven Sisters'. This is the most conspicuous of all clusters, and can be seen without a telescope; most people can see seven or eight stars in it. Even binoculars will show many more

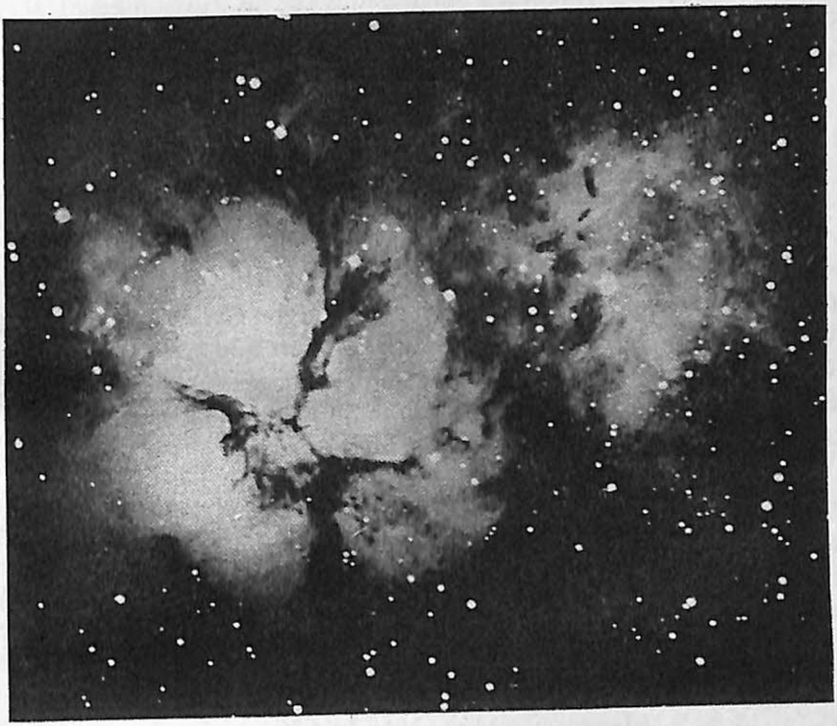
Two star-clusters in the constellation of Perseus. These can be seen without a telescope, and a small instrument will show them well

The nebulæ are particularly interesting to us, because astronomers believe that they are the birthplaces of the stars. A star begins its career as a mass of gas and dust, which slowly shrinks until it becomes hot and starts to shine. Of course, the whole process takes a very long time, but it is thought that new stars are gradually forming inside gas-clouds such as the Sword of Orion. More than five thousand million years ago, our Sun, too, was born inside one of these nebulæ.



The 'Horse's Head' in Orion. The 'head' itself is made up of a dark mass, blotting out the stars behind it. The Great Nebula in Orion lies in the 'Sword', below the Belt, and even without a telescope you can see it as a hazy patch

A bright nebula shines because it is lit up by the stars inside it; sometimes the effect of the stars' radiation makes the gas luminous on its own account. If there are no suitable stars in the nebula, there is nothing to light up the gas, and we find a patch of sky where almost no stars are to be seen; we know that this is a dark nebula, blotting out the light of the stars which lie beyond. There is a famous dark nebula in Orion, the so-called Horse's Head, while in the Southern Cross lies the dark nebula called the Coal Sack.



The 'Trifid Nebula', a tremendous gas-cloud in the star-group of the Archer

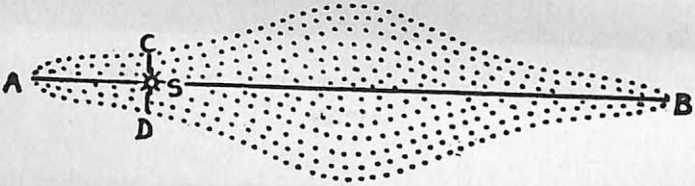
Though a nebula looks so conspicuous when photographed through a large telescope, the gas of which it is made is really very thin—millions of times less dense than the air we breathe.

Only a few nebulæ are visible to the naked eye, but even a small telescope will show many more, such as the celebrated Trifid Nebula in the constellation of the Archer. There is a splendid nebula, too, in the star-group of the Ship, not far from Canopus—but if you want to see it you must travel south towards the equator, since, like Canopus, the nebula never rises above the horizon in Britain.

The Milky Way

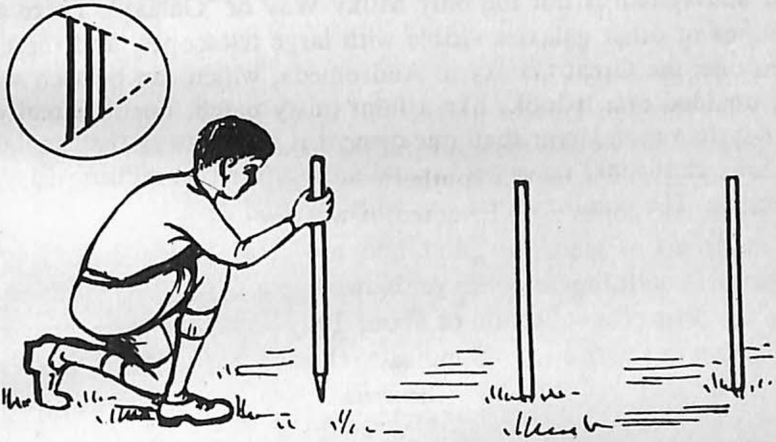
Everyone must have noticed the Milky Way, which stretches across the sky, and is very conspicuous on a dark night. On a winter evening we can follow its path from between Orion and the Twins, past Capella, through Perseus and the W of Cassiopeia, into the Swan; in the summer we can trace it from the Swan through the Eagle, near Altair, and down to the southern horizon.

When telescopes were invented, it was found that the Milky Way is made up of stars too faint and too close together to be seen separately with the unaided eye. Nowadays it is known that our Sun is a member of a collection of about 100,000 million stars, arranged as shown in this picture. (S indicates the position of the Sun.) When we look along the line SA or SB, we see a great many stars almost in the same direction, and this causes the Milky Way appearance; when we look along SC or SD, we see fewer stars. This shows us that the stars in the Milky Way are not really close together.



One way to prove this is to stick some cricket stumps in a field, as shown in the next picture, and then to look at them from behind. The stumps will seem close together, because they will lie almost one behind the other.

With binoculars, or our home-made telescope, it is worth while to search the rich parts of the Milky Way. Double stars, clusters and other objects will be found in plenty, and there is always something interesting to see.

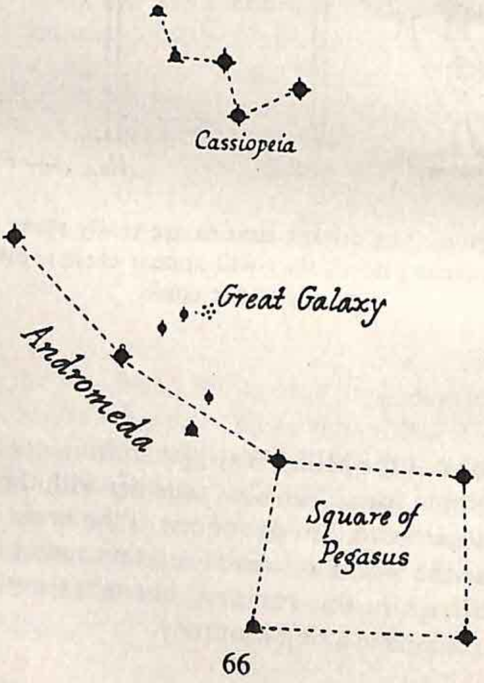


Effect of perspective. The cricket stumps are really some distance apart, but to the boy kneeling down they will appear close together—as shown in the upper circle

If we could look at the Milky Way system from outside, we should see that it is spiral in form. The Sun, together with the Earth and the other planets, lies close to the edge of one of the spiral arms. We have found, too, that the whole system is rotating round its centre. The Sun naturally shares in this rotation, but takes over two hundred million years to complete a single journey.

The Galaxies

Our star-system is not the only Milky Way or 'Galaxy'. There are millions of other galaxies visible with large telescopes, and there is even one, the Great Galaxy in Andromeda, which can be seen with the unaided eye. It looks like a faint misty patch, but it is really a star-system even larger than our own; it is so far away that its light, moving at 186,000 miles per second, takes over two million years to reach us. The picture shows you where to find it.



The Andromeda Galaxy is spiral in shape, like a Catherine-wheel, but as it lies partly edge-on to us the spiral effect is rather lost. Other galaxies, though not all, share this spiral shape, but large telescopes are needed to show them well. As we have seen, it is now known that our own Galaxy is itself a spiral.

How were these galaxies formed? We have to admit that we do not really know, and that there are many problems waiting to be solved. It is believed that most of the galaxies are racing away from us, and that the whole universe is expanding; but though many suggestions have been made to explain this remarkable fact, the universe in which we live still remains a puzzle to us.

A 'Galaxy' in the constellation of Virgo, photographed with the 200-inch Mt. Wilson reflector. This galaxy is so distant that its light takes 8 million years to reach us. It is often called the 'Saturn Nebula'. Unfortunately it cannot be well seen except with the help of a large telescope

Do You Want to Be an Astronomer?

If you have been interested in what I have written in this book, you may decide that you would like to make a real hobby of astronomy. If so, you will be wise to read some of the books listed on page 72, and you may like to join an association such as the Junior Astronomical Society, or a club in your local town, so that you can make friends with others of your own age and similar interests.

Astronomy as a hobby is open to everyone, but astronomy as a full-time career is different. If you are going to become a professional scientist, whether an astronomer, physicist, chemist or a worker in any other branch, it is most necessary to take a 'degree'. This can be done at a college or university, or by private study; but the first step must always be to pass your school leaving examinations, since otherwise you cannot hope to make a successful career out of science. As well as the actual science subjects, your school certificate should include a good pass in English, since it is always necessary to be able to write clearly and well.

When you have passed your school leaving examinations, and have taken a degree such as the Bachelor of Science, you will see where your main interests lie; but always remember that school examinations must be done first. To think of becoming a scientist without passing them is as hopeless as dreaming of playing first-class cricket without learning how to play a straight bat.

Relatively few people will want to make a career of astronomy, but as a hobby it cannot be bettered. You will make plenty of new friends, and you can always enjoy yourself among the stars.

Astronomical Societies

There are many astronomical societies in Great Britain. The leading amateur organization is the British Astronomical Association (secretarial address, 303 Bath Road, Hounslow West, Middlesex) which has thousands of members; it was founded more than seventy years ago, and publishes a regular Journal as well as an annual Handbook.

Affiliated to this association is the Junior Astronomical Society (secretarial address, 44 Cedar Way, Basingstoke, Hampshire). It was formed in 1952, to help young would-be astronomers, and now has a membership of almost one thousand. Meetings are held in London four times a year, at Caxton Hall (not far from Victoria Station), and there is a quarterly journal, *Hermes*. The subscription is ten shillings per year.

In addition, there are many local astronomical societies scattered over Britain; most large cities have them—for instance Bristol, Leeds, Liverpool, Newcastle and Norwich, while in Edinburgh the city astronomical society has its headquarters at the Calton Hall Observatory. A full list of local societies is given in the annual *Yearbook of Astronomy*.

There are many advantages in joining a society of some kind—provided, of course, that you are seriously interested in astronomy. You will be able to exchange ideas with others, and learn at the same time; you will be able to go to meetings, if you can spare the time from your school work.

Some Useful Books

There are many books on astronomy, and the following list is not at all complete. Books marked with a * are intended specially for readers of school age.

BAXTER, W. M., *The Sun and the Amateur Astronomer*, Lutterworth Press, 1962.

BEET, E. A., **Guide to the Sky*, Cambridge University Press, 1953.
**The Young Astronomer*, Nelson, 1962.

BRANLEY, F. M., **Experiments in Sky Watching*, Faber and Faber, 1962.

BRINTON, HENRY, **Measuring the Universe*, Methuen's Outlines, 1962.

FEA, K., *The Young Astronomer's Companion*, Cresset Press, 1962.

MOORE, PATRICK, *Survey of the Moon*, Eyre and Spottiswoode, 1963.
The Amateur Astronomer, Lutterworth Press, 1963.
**The Solar System*, Methuen's Outlines, 1962.
**The Boy's Book of Astronomy*, Burke Publishing Co., 1961.
Astronomy, Oldbourne Press, 1962.

MOORE, PATRICK, and MURDIN, P., **The Astronomer's Telescope*, Brockhampton Press, 1962.

MUIRDEN, J., **The Sun's Family*, Weidenfeld and Nicolson, 1962.
Astronomy with Binoculars, Faber and Faber, 1963.

NORTON, A. P., *Norton's Star Atlas*, Gall and Inglis, 1961.

RICHARDSON, R. S., *The Fascinating World of Astronomy*, Faber and Faber, 1962.

ROTH, G., *The Amateur Astronomer and his Telescope*, Faber and Faber, 1963.

WILKINS, H. P., **Instructions to Young Astronomers*, Museum Press, 1957.

The annual *Yearbook of Astronomy* is published by Eyre and Spottiswoode; the editor is J. G. Porter.

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